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Physical World, Units and Dimension and Errors in Measurement

SOLUTIONS

Beginner Box - 1

1. Dimension of gravitational constant
$= [M^{-1}L^3T^{-2}]$

$$n_2 = n_1\left[\frac{M_1}{M_2}\right]^{-1}\left[\frac{L_1}{L_2}\right]^{3}\left[\frac{T_1}{T_2}\right]^{-2}$$

here,

MKS	CGS
$n_1 = 6.67 \times 10^{-11}$	$n_2 = ?$
$M_1 = kg$	$M_2 = g$
$L_1 = m$	$L_2 = cm$
$T_1 = sec$	$T_2 = sec$

$$n_2 = 6.67 \times 10^{-11}\left[\frac{kg}{g}\right]^{-1}\left[\frac{m}{cm}\right]^{3}\left[\frac{sec}{sec}\right]^{-2}$$

$= 6.67 \times 10^{-11} \times 10^{-3} \times 10^{6} \times 1$
$= 6.67 \times 10^{-8}$

Beginner Box - 2

2. (a) [Temperature] = [K]

(b) $KE = \frac{1}{2}mv^2$

$\Rightarrow [KE] = [m][v]^2 = M(LT^{-1})^2 = [ML^2T^{-2}]$

(c) $P = \frac{F}{A} \Rightarrow [P] = \frac{[F]}{[A]} = \frac{MLT^{-2}}{L^2} = [ML^{-1}T^{-2}]$

(d) $\omega = \frac{v}{r} \Rightarrow [\omega] = \frac{[v]}{[r]} = \frac{LT^{-1}}{L} = [T^{-1}]$

3. $E = hf \Rightarrow h = \frac{E}{f} \Rightarrow [h] = \frac{[E]}{[f]} = \frac{ML^2T^{-2}}{T^{-1}} = [ML^2T^{-1}]$

4. $F \propto m^a v^b r^c \Rightarrow F = k m^a v^b r^c$
$\Rightarrow [M^1L^1T^{-2}] = [M]^a[L^1T^{-1}]^b[L]^c = [M]^a[L]^{b+c}[T]^{-b}$
by comparison a = 1, b = 2, c = –1

So $F = k\frac{mv^2}{r}$

Beginner Box - 4

2. Radius of circle $= \frac{1.06}{2} = 0.53$ m

Area of circle $= \pi r^2$
$= 3.14 \times (0.53)^2 = 0.882\ m^2$ (3 SF)

3. $3.9 \times 10^5 - 2.5 \times 10^4 = 3.9 \times 10^5 - 0.25 \times 10^5$
$= 3.65 \times 10^5 = 3.6 \times 10^5$ (2 SF)

4. (a) Total mass of the box
= 2.3 kg + 20.15 g + 20.17 g = 2.34017 kg
= 2.3 kg
(b) Difference in masses of gold pieces
= 20.17 g – 20.15 g = 0.02 g

Beginner Box - 6

1. $L = L_1 + L_2 = (1.8 \pm 0.2) + (2.3 \pm 0.1)$
$= 4.1 \pm 0.3$ m

2. Elongation $= L_2 - L_1$
$= (155.3 \pm 0.2) - (153.7 \pm 0.6)$
$= (1.6 \pm 0.8)$ cm

3. Let y = AB

$$\frac{\Delta y}{y} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

$y = 2.5 \times 0.1 = 0.25$

$$\frac{\Delta y}{0.25} = \frac{0.5}{2.5} + \frac{0.01}{0.10}$$

$\Rightarrow \Delta y = 0.075 = 0.08$ (2SF)

4. Surface area of sphere $= 4\pi r^2$
$= 4 \times 3.14 \times (2.1)^2 = 55.3896 = 55.4$ (3SF)

$$\Delta A = 2\frac{\Delta r}{r} \times A = 2 \times \frac{0.5}{2.1} \times 55.4$$

$= 26.376 = 26.4$ (3SF)

5. $x = \frac{a^3b^2}{\sqrt{cd}}$

$$\frac{\Delta x}{x} = 3\frac{\Delta a}{a} + 2\frac{\Delta b}{b} + \frac{1}{2}\frac{\Delta c}{c} + \frac{1}{2}\frac{\Delta d}{d}$$

$$\frac{\Delta x}{x} \times 100 = 3 \times 1 + 2 \times 3 + 4 \times 1/2 + 2 \times 1/2$$

$= 12\%$

6. $V = \frac{16.0}{4.0} = 4.0$ m/s

$\because \frac{\Delta V}{V} = \frac{\Delta s}{s} + \frac{\Delta t}{t}$

$\because \Delta V = (4.0)\left[\frac{0.4}{16.0} + \frac{0.2}{4.0}\right] = 4.0[0.2 + 0.5]$

$= 0.28$ after (rounding off) 0.3

$\Rightarrow$ Speed (4.0 ± 0.3) m/s

Beginner Box - 7

1. L.C. = $\left(\frac{b-a}{b}\right)$ M.S.D. = $\left(\frac{20-19}{20}\right) \times \frac{1}{10}$ cm

= 0.005 cm

2. Pitch = $\frac{4}{8}$ mm = 0.5 mm

L.C. = $\frac{0.5}{100}$ mm = 0.005 mm

3. L.C. = $\frac{0.0625}{250}$ cm = 2.5×10^{-4} cm